variation in 1996 survival outside of the historical relationship, suggesting either egg production was much lower than in 1994 or some other factor caused the poor survival. What level of egg production would be required to bring the 1996 residual within the historical range of residual variation? The 1996 egg production would have had to decline to about one-third of the 1994 egg production just to be at the limits (2 standard deviations) of the historical variation. Is that a believable decline in egg production over the past 2 years? Although dramatic, it is plausible if the lack of stocking and increased mortality have sharply reduced abundance of older, more fecund spawners. When the 1996 abundance estimates are available, we can determine if egg production was low enough in 1995 and 1996 to explain the low young bass indices.

References

Foss, S.F., and L.W. Miller. 1996. Summer Tow-Net Survey: 1995 Young-of-the-Year Striped Bass Index. IEP *Newsletter* (9)3:11.

IESP. 1991. *1990 Annual Report*. 123 pp.

Miller, L.W., and J. Arnold. 1994. Striped bass egg and larva survey. Pages 31-42 in *1992 Annual Report*. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. 126 pp.

New Publication

- *Stress Proteins in Amphipods as Biomarkers of Sediment Pollution in San Francisco Bay*. Ingeborg Werner, Kurt F. Kline, James T. Hollibaugh. Technical Report 48.

For a copy, contact Lisa Batiste (916/277-7541; lbatiste@water.ca.gov)

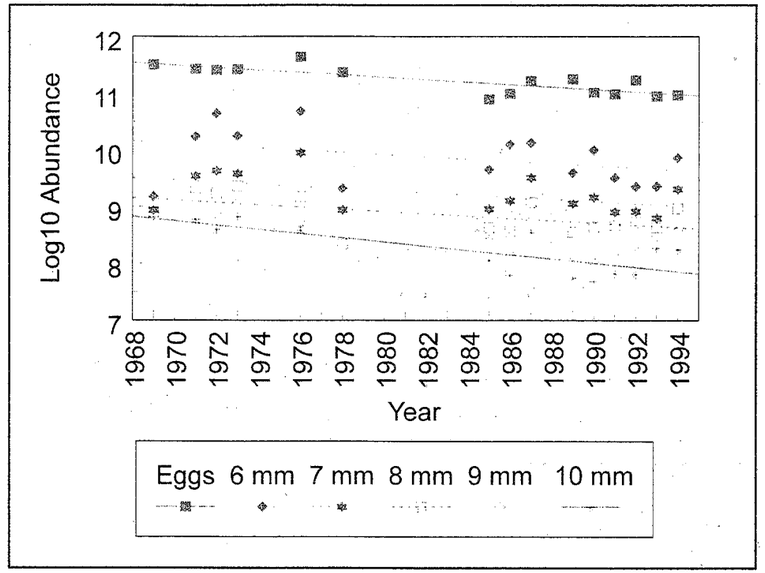

Figure 8
REGRESSION TRENDS FOR THE EGG PRODUCTION INDEX AND 6-10mm LARVAE FOR EGG AND LARVAL SURVEY
For years of record where valid indices are available.
We used the 1969 estimate of egg production for 1968.

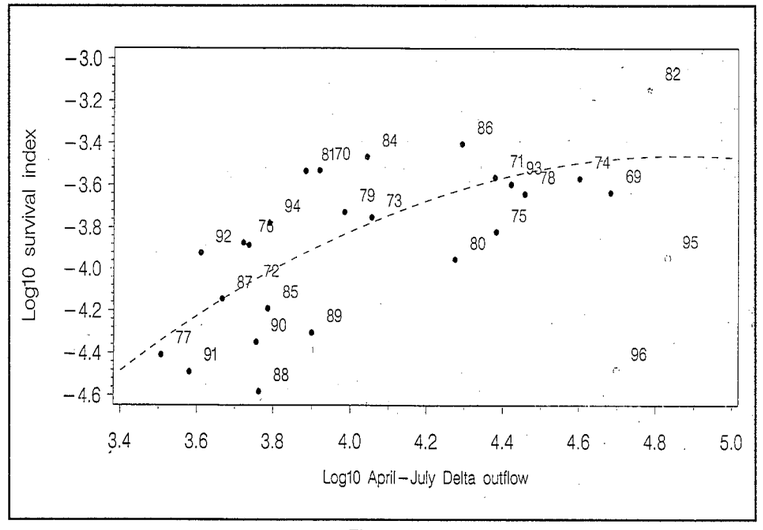

Figure 9
RELATIONSHIP BETWEEN THE LOG10 OF THE SURVIVAL INDEX (38 mm/egg production) AND THE LOG10 OF THE MEAN APRIL-JULY OUTFLOW FOR YEARS OF RECORD, 1969-1994
Survival was estimated for 1995 and 1996 using the 1994 estimate of egg production.

1995 Splittail Spawning Investigations

Randall Baxter, William Harrell, and Lenny Grimaldo

In 1995, several projects were conducted to provide information on splittail spawning: a recreational angler survey near Sacramento; boat electrofishing in a flooded riparian area in the lower Sutter Bypass; and larval sampling in tributary mouths and in the Yolo and Sutter bypass outflows. These studies provided information on the status of a recreational fishery for splittail, on splittail migration and spawn timing, and on spawning locations. A key finding was the relatively high number of splittail larvae collected in the Yolo Bypass outflow, indicating the importance of the area for splittail spawning.

Recreational Angler Survey

On 17 days between February 17 and April 6, 1995, we conducted a splittail creel census on the Sacramento and Feather rivers. Anglers were interviewed about splittail catch and time spent fishing. With anglers' consent, fish were measured to the nearest millimeter fork length and checked for ripeness. In some cases, anglers would not allow investigators to measure the splittail, but catch counts were obtained. In a few cases, investigators relied on angler-reported splittail catches when fish were not available for examination. The survey was conducted primarily on the Sacramento River near the Sacramento, but some anglers were contacted farther upstream and downstream on the Sacramento River and on the lower Feather River.

On the Sacramento River, investigators interviewed 363 anglers and counted 447 splittail. Investigators interviewed 12 anglers on the Feather River, with a total of 12 splittail. Anglers were observed with splittail from Hood at river mile 38 upstream to Verona (RM 75) on the Sacramento River and downstream of the Highway 99 bridge on the Feather River (RM 7, 9; Figure 1). Most contacts were between Hood and Discovery Park on the Sacramento River (Table 1). A few splittail were also caught in the lower Feather River, but fishing effort (and survey effort) was minimal.

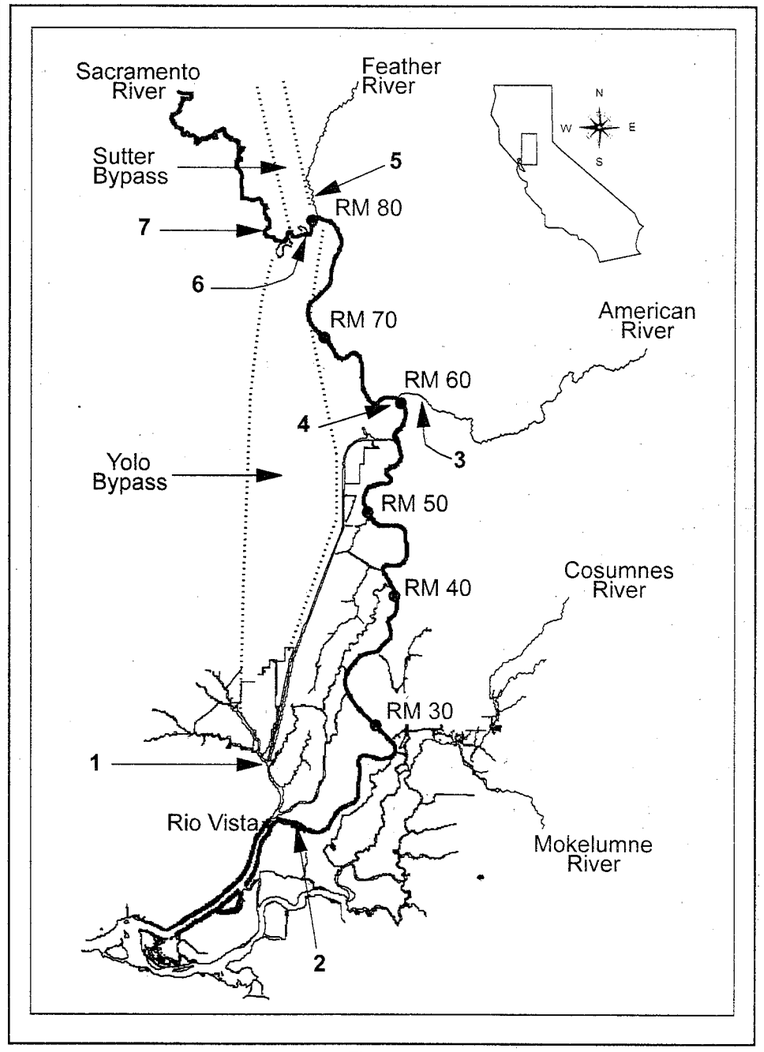

Figure 1
SAMPLING LOCATIONS, 1995 SPLITTAIL SPAWNING INVESTIGATIONS
Electrofishing was conducted primarily in the Sacramento River at the lower end of the Sutter Bypass. Larval sampling locations were: (1) Cache Slough at the south end of Prospect Island; (2) Sacramento River near Isleton; (3) American River upstream of Highway 5 crossing; (4) Sacramento River on the west side across from the mouth of the American River; (5) Feather River upstream of the confluence with the Sutter Bypass; (6) Sacramento River at the confluence with the Sutter Bypass; (7) Sacramento River upstream of the confluence with the Sutter Bypass.

Anglers were not asked what species they were targeting, but many volunteered this information. Targeted species included splittail, catfish, and sturgeon. In early April, many anglers switched from targeting splittail to targeting striped bass. Some splittail were caught by anglers attempting to catch other species. The primary bait used by splittail anglers was red worms, but anglers also reported success using sardines, minnows, chicken liver, and artificial lures know as shad darts.

Unripe splittail were observed throughout the sampling period. The first ripe splittail was observed on February 28, and by early March many splittail were ripe (Table 2). Among ripe fish, females outnumbered males by about 2 to 1. Splittail were 165-375mm FL ($\bar{x}$=279 mm FL).

Overall, this survey noted the persistence of a small but dedicated winter fishery for adult splittail on the Sacramento River. This fishery was previously identified by Caywood (1974) and more recently by a DFG survey (1991-1994, Lynn Wixom, DFG Region II, pers. comm. April 1994). Angler comments in February indicated that splittail were caught near Sacramento as early as January. It appeared that splittail were unripe when they entered the river then ripened and spawned later. The 447 splittail recorded during the creel census is likely a minimum total catch for the 17 days of angler interviews and suggests that a total seasonal catch was perhaps in the low thousands or higher.

Table 1
SPLITTAIL CATCH AND NUMBER OF ANGLERS CONTACTED DURING 1995 SURVEY ON THE SACRAMENTO RIVER
River miles are measured upstream from confluence with San Joaquin River.

River Mile	Splittail Catch	Number of Anglers
31-35	0	0
36-40	4	16
41-45	39	34
46-50	145	94
51-55	140	74
56-60	105	116
61-65	0	6
66-70	6	5
71-75	7	10
76-80	0	6
81-85	0	2
Total	447	361

Electrofishing for Adult Splittail

To locate potential splittail spawning areas, electrofishing was conducted using a 19-foot Smith-Root electrofishing boat during 5 days (March 28-29, April 10, May 12, and June 2, 1995). As a result of reconnaissance sampling on March 28-29 in the Cosumnes, Mokelumne, and Sacramento rivers and safety concerns associated with sampling during extremely high flows, sampling was limited primarily to the Sacramento River at the lower end of the Sutter Bypass (Figure 1). Three locations representing different flooded riparian habitat types were selected and sampled monthly: flooded trees, brush, and berries backed by dry land; flooded trees, grass, and brush backed by the head weir of the Yolo Bypass; and flooded trees, brush, grass, and berries backed by flooded fields in the Sutter Bypass. A forth site in the bypass area was sampled once in May. Areas sampled on the 3 days following reconnaissance were: three sites in the bypass and two sites in the Feather River below Highway 99; four sites in the bypass and; three sites in the bypass.

Twenty-two adult splittail were collected in Sutter Bypass sites, but no splittail were collected from the Cosumnes, Mokelumne or Feather river sites (Table 3). Results suggest possible high spawner use by adult splittail in the Sutter Bypass; however, sampling was not sufficient to rule out spawner use at the other sites.

Most splittail were collected from the north side of the Sacramento River channel in flooded riparian zones covered primarily by trees and brush (21 splittail in seven 20-minute samples). Both north shore locations received some flow from the Sutter Bypass (water flowed from the bypass through the riparian zone and into the Sacramento River). Conversely, the south side produced only one splittail (in four 20-minute samples). The two south shoreline locations (one was sampled on a single date) each had substantial areas of flooded grasses and annual plants in addition to some trees and brush.

Table 2
REPRODUCTIVE STATUS AND SEX OF SPLITTAIL EXAMINED DURING THE 1996 ANGLER SURVEY ON THE SACRAMENTO RIVER
Fish were categorized as ripe when gametes were released after moderate pressure was applied to the posterior abdomen.
Fish were categorized as spent when posterior abdomen was flaccid.

	Date								
	2/17	2/23	2/25	2/28	3/1	3/2	3/6	3/7	4/4
Unripe	5	16	57	53	24	5	5	11	1
Ripe				2	22	8	3	8	4
Spent								2	
Male					6	4	1	2	3
Female				2	16	4	2	6	1
Unknown	5	16	57	53	24	5	5	13	1
Total	5	16	57	55	46	13	8	21	5

Table 3
CATCH DURING 1995 BOAT ELECTROFISHING FOR ADULT SPLITTAIL

Species	Date				
	3/28	3/29	4/10	5/12	6/2
American shad				1	
Bluegill sunfish		17	2		
Carp	2	7		2	4
Channel catfish		1			
Chinook salmon	1	9	20	2	2
Delta smelt		2			
Golden shiner		1			
Hardhead	1				
Hitch	2				
Inland silversides		2			
Largemouth bass		2			
Rainbow trout		1	6		
Redear sunfish	1	6			
Sacramento sucker	1		1	1	8
Sacramento squawfish	4	2	4	3	5
Smallmouth bass	1	2			1
Splittail	5		12	1	4
Striped bass			2	1	1
Threadfin shad		3			
Tule perch	6				
White catfish	1		1		
Total	25	55	48	11	25

Areas sampled were:
March 28 — Sacramento River channel at the bottom of the Sutter Bypass and a few miles upstream.
March 29 — Cosumnes and Mokelumne rivers from the Cosumnes Preserve to Wimpy's.
April 10 — Three sites in the Sutter Bypass and two sites in the Feather River below Highway 99.
May 12 — Four sites in the Sutter Bypass.
June 2 — Three sites in the Sutter Bypass.

Splittail electrofished in Sutter Bypass ranged from 227 to 355mm FL ($\bar{x}$=296 mm FL), and their weight ranged from 150 to 660 grams ($\bar{x}$=378 grams). The number of splittail collected was insufficient to statistically determine whether there was a trend toward smaller fish later in the spawning season, as noted by Caywood (1974).

Electrofishing collected adult splittail in the Sutter Bypass area of the Sacramento River from March through early June. Additional electrofishing for juvenile splittail in July failed to capture any adult fish. Given the high turbidity and difficulty of sampling fish within vegetation, the success rate in 1995 appeared high and suggests that splittail are present in high numbers at various times. In conjunction with the angler survey data and angler reports, these data indicate that adult splittail were in the Sacramento River (near Sacramento) for at least 5 months in 1995; however, fish collected may represent successive waves of spawners rather than a single group of individuals that remained through the entire period.

Larval Sampling

Seven locations were selected to estimate the degree to which larval splittail were being swept out of the bypasses and tributaries versus adjacent river channels. Each location was visited once during April 19-21, 1995. Sampling consisted of four 10-minute oblique plankton tows with two near shore and two near the center of the channel. Sampling locations (Figure 1) were:

- Cache Slough at the south end of Prospect Island (Yolo bypass hatched fish).
- Sacramento River near Isleton (larvae in the main stem).
- American River upstream of Highway 5 crossing (American River hatched fish).
- Sacramento River on the west side across from the mouth of the American River.
- Feather River upstream of the confluence with the Sutter Bypass.
- Sacramento River at the confluence with the Sutter bypass (Sutter Bypass hatched fish).
- Sacramento River upstream of the confluence with the Sutter Bypass.

Splittail larvae were collected at four of the seven sampling locations (Table 4). Location had a significant effect on larval catch per unit effort (catch per thousand cubic meters; $F=48.2$, 7 df, $p<0.001$, ANOVA). CPUE from Cache Slough was significantly higher than other locations ($p<0.05$). CPUE from the Sacramento River at the Sutter Bypass was significantly different from all other locations ($p<0.05$), except the Sacramento River above the confluence with the American River ($p=0.063$; the next location downstream of the Sutter Bypass). No other significant differences were detected between stations.

Study results support the theory that flooded bypasses in the Sacramento River drainage provide important spawning habitat. The catch per tow of splittail larvae from samples taken below the Yolo Bypass included the highest single catch observed to date when compared with 1988-1995 plankton survey data (DFG unpublished data, splittail larvae identified by Johnson Wang). Also, some

Table 4
CATCH OF LARVAE DURING LARVAL SPLITTAIL SURVEY, APRIL 19-21, 1995

	Sacramento R near Isleton	Cache Slough at Yolo Bypass	American R above Hwy 5 Bridge	Sacramento R above American R Confluence	Feather R above Sacramento R Confluence	Sacramento R at Sutter Bypass Confluence	Sacramento R above Sutter Bypass	Total
Centrarchid spp.	5	11		1	1	12		30
Cyprinid spp.		6		3	1	6	1	17
Delta smelt			17		5			22
Log perch	3	5		2		8	1	19
Longfin smelt	2							2
Prickly sculpin	21	363	32	69	41	73	116	715
Sacramento sucker				1	1		2	4
Splittail	3	29		10		14		56
Wakasagi			1		6			7
White sturgeon	4							4
Total	38	414	50	86	55	114	120	877

catches from below the Sutter Bypass were higher than average. Sampling took place over a limited time span, however, and was not repeated. As a result, effort was insufficient to rule out the potential for spawning in the Sacramento River above the Sutter Bypass or in the Feather or American rivers.

Delta smelt and wakasagi were also collected from the American and Feather rivers (Table 4). Neither species was collected at any other location. In the American River, delta smelt were more numerous than wakasagi; the reverse was observed in the Feather River. Two longfin smelt were collected at the Isleton location.

Conclusion

Results of these studies and those of Baxter (1994) — no adult splittail were caught in the Sacramento River during August 1994 — support the observation of Caywood (1974), that splittail migrate from the delta to the rivers after the first fall or winter rains to forage and spawn. In this scenario, the delta, Suisun Marsh, Suisun Bay, and other tidal fresh and brackish water areas constitute adult summer and fall habitat, whereas riverine areas are used during winter and spring (some proportion of the splittail population may not migrate or may not go far, especially if the delta is fresh during the spawning season). The importance of the rivers for foraging can be inferred from a number of pieces of information:

- Splittail were being caught in the river for 2 months before the first ripe individuals were observed.
- Splittail were caught using red worms for bait, indicating feeding was taking place.
- Adults appear in the fishery (DFG unpub. data) and in fish salvage (DWR and USBR 1994) earlier in the year and in greater numbers in "wet" years, when terrestrial foraging opportunities are greater, than in "dry" years.
- The potentially long duration of riverine residence (up to 5 months in 1995) would necessitate some feeding. Flooding and associated foraging opportunities may not only instigate upstream migration, but may also prolong riverine residence.

In 1995, the persistence of adult splittail in the Sacramento River near Miller Park, Discovery Park, and the lower end of the Sutter Bypass suggests that these are important foraging and spawning areas or are near such areas. Larval sampling confirmed that spawning did take place in both the Sutter and Yolo bypasses and, based on relatively high larval numbers, suggests that the bypasses were important spawning habitats. Each of these locations has areas of reduced water velocity and, at least at high flows, access to flooded terrestrial habitat. During high flows, the bypasses provide the most extensive areas of accessible terrestrial habitat in the lower Sacramento River. Adult access to flooded terrestrial habitats for foraging and spawning is believed to be necessary for the production of a strong year class (Caywood 1974). Since this floodplain access is related to streamflow, improved foraging and spawning success represent a couple mechanisms that may underlie the outflow abundance relationships observed by Caywood (1974), Moyle and Daniels (1983), DFG (1992), and the bypass inundation abundance relationship observed by Sommer *et al* (In prep.). Further studies at these locations can help identify what factors influence when and specifically where spawning takes place and whether it leads to a strong year class.

References

Baxter, R.D. 1994. Preliminary results of a summer gill-net survey for Sacramento splittail. IEP *Newsletter* Autumn 1994. pp. 14-15.

Daniels, R.A., and P.B. Moyle. 1983. Life history of splittail (Cyprinidae: Pogonichthys macrolepidotus) in the Sacramento-San Joaquin Estuary. *Fishery Bulletin* 81(3): 647-654.

Department of Water Resources and U. S. Bureau of Reclamation (DWR and USBR). 1994. *Biological Assessment: Effects of the Central Valley Project and the State Water Project on Delta smelt and Sacramento Splittail.* Prepared for U.S. Fish and Wildlife Service. 230 pp.

Sommer, T., R.D. Baxter, and B. Herbold. (In prep). The resilience of splittail in the Sacramento-San Joaquin Estuary. To be submitted to Trans. Am. Fish Soc.

IEP Surfboard

Doug Demko

Each edition of the IEP Surfboard will introduce about 15 useful, interesting, or entertaining Web sites. The focus will be on sites related to fish, water issues, or the environment, primarily in the Central Valley and bay/delta regions. This edition focuses on popular, easily located Web sites; subsequent articles will preview more obscure sites.

In addition to providing each Uniform Resource Locator in this article, a copy of this article with links to each Web site will be posted at http://www.spcramer.com. Instead of typing in URLs, read this article on-line and jump from site to site with your mouse. You can also add your favorite site to a list of links submitted by other IEP *Newsletter* subscribers. If you like, include a review of the site you contribute.

Experienced Web users are probably already familiar with most of the agency home pages. If you are new to the Internet, put these sites at the top of your surfing list:

- IEP (http://wwwiep.water.ca.gov/)
- USFWS (http://www.delta.dfg.ca.gov/usfws/index.html)
- DWR (http://wwwdwr.water.ca.gov/)
- NMFS (http://kingfish.ssp.nmfs.gov/)
- DFG (http://www.dfg.ca.gov/) OR (http://www.delta.dfg.ca.gov/index.html)
- USGS (http://water.wr.usgs.gov/) OR (http://sfbay.wr.usgs.gov/)

Another great place to begin surfing:

- American Fisheries Society (http://www.esd.ornl.gov/societies/AFS/)

All of these sites are easily navigated and provide information for the public as well as environmental professionals.

USGS and DWR maintain Web sites where current and historical streamflow data can be viewed and downloaded for many California streams. The California Data Exchange Center has flow data in hourly, daily, and monthly formats (http://cyclone.water.ca.gov/). Data such as snowpack and water temperature are also present. At the USGS page, locating the desired flow monitoring station is simple due to a "clickable" image map. The USGS also maintains a Web site specific to the bay/delta region (http://sfbay.wr.usgs.gov/). In addition to a "near real-time" wind pattern map, you'll find detailed information on water quality and salinity in the bay/delta area and learn about current research.

The DFG Bay-Delta server includes pictures and information on northern pike and alligator gar captured in California waters (http://www.delta.dfg.ca.gov/index.html). The alligator gar photographs are worth the wait (I wouldn't touch it without gloves either). While there, don't miss pictures of Barney, the harbor seal pup captured at Skinner Fish Facility. The amount and diversity of information present and the useful links to other sites make the DFG Bay-Delta home page a good stop.

To find out what El Niño is or read about the latest El Niño research, visit the "El Niño Theme Page" at http://www.pmel.noaa.gov/toga-tao/el-niño/home.html Although the graphics can be hard to read, complete descriptions and great links make the collection of pages superior, as indicated by the awards they have received.

If you think things are rough where you work, or if your fingers get cold while measuring fish, check out the Yukon Fish and Game Association home page (http://www.yukonweb.wis.net/community/yfga/). While there, visit the longest wooden fish ladder in the world (hint: it's 400 yards long and it's not in Red Bluff).